Hawaiian Records of Folliculinids (Protozoa) from Submerged Wood[1]

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ABSTRACT: To folliculinids in Hawaii, taken from naturally submerged objects (*Halofolliculina annulata, Ascobius simplex, Metafolliculina andrewsi*) and from submerged glass-plate panels (*Metafolliculina nordgardi, Parafolliculina violaceae*), are added those from Douglas fir panels riddled by subsistent teredines and *Limnoria: Eufolliculina lignicola, Mirofolliculina limnoriae,* and *Lagotia viridis.* Variations in loricae and moniliform nuclear components are illustrated and discussed.

THUS FAR five species of folliculinids embracing four genera have been recorded for Hawaii (Matthews, 1962). Of these, *Halofolliculina annulata, Lagotia simplex,* and *Metafolliculina andrewsi* were taken from submerged naturally-occurring objects, whereas *Metafolliculina nordgardi* and *Parafolliculina violaceae* were taken from submerged glass-plate panels.

Douglas fir (*Pseudotsuga taxifolia?*) frames supporting these panels (Matthews, 1962, fig. 1), subsequently honeycombed by subsistent teredines and Limnoria, were broken apart; the tortuous burrows and their sequestered organisms revealed the folliculinids recorded here.

Folliculina lignicola, Fauré-Fremiet 1936, La famille des Folliculinidae. Mém. Mus. d'Hist. Nat. de Belg. (Ser. 2), 3:1129–1175.

Eufolliculina lignicola, Hadzi 1951.

This slender folliculinid (reassigned by Hadzi [1951] to *Eufolliculina lignicola* [Fauré-Fremiet]) was abundant in tracheids opened by burrowing gribbles. In riddled wood frames examined November 21, 1961 (corroborated January 11, 1962) *E. lignicola* was the most abundant, although not the most sequestered, folliculinid. In fact, just outside the burrows, attached especially to calcareous tubes of serpulid worms (*Spirobis sp.* and *Mercierella sp.*) were numerous folliculinids whose sacs, necks, and moniliform nuclei fell well within those limits prescribed for *E. lignicola.* Thus, as suggested by Mohr (1959: 86) *E. lignicola* is not restricted to tracheids. Mention should be made, however, that although they were abundant on calcareous tubes of serpulids, none was attached to calcareous walls of abandoned teredo burrows, shells, or pallets, although these apparently afforded similar attachment potentials.

As frequently observed in other folliculinids, sac length, width, and height often varied with site conditions. In young colonies, composed of few folliculinids, ample space resulted in normal sac formation; whereas in old colonies, composed of many folliculinids, limited space resulted in "abnormal" sac formation. Thus, sacs lying contiguously were usually longer, whereas those laid one on another were usually shorter, etc. Despite their occurrence on serpulid shells, certain restrictive sites seemed preferred. A common restrictive site is illustrated in Figure 1. Although the neck (*c*) was free and always extended at an angle from the opened portion of a tracheid (*h*), the sac (*f*) usually was confined, at least in part, in the unopened portion (*g*). This condition, which resulted in a long narrow sac (up to 166μ), affected in no way either the length of the neck (*c*) or the number of its spiral whorls (*d*). Thus, regardless of the

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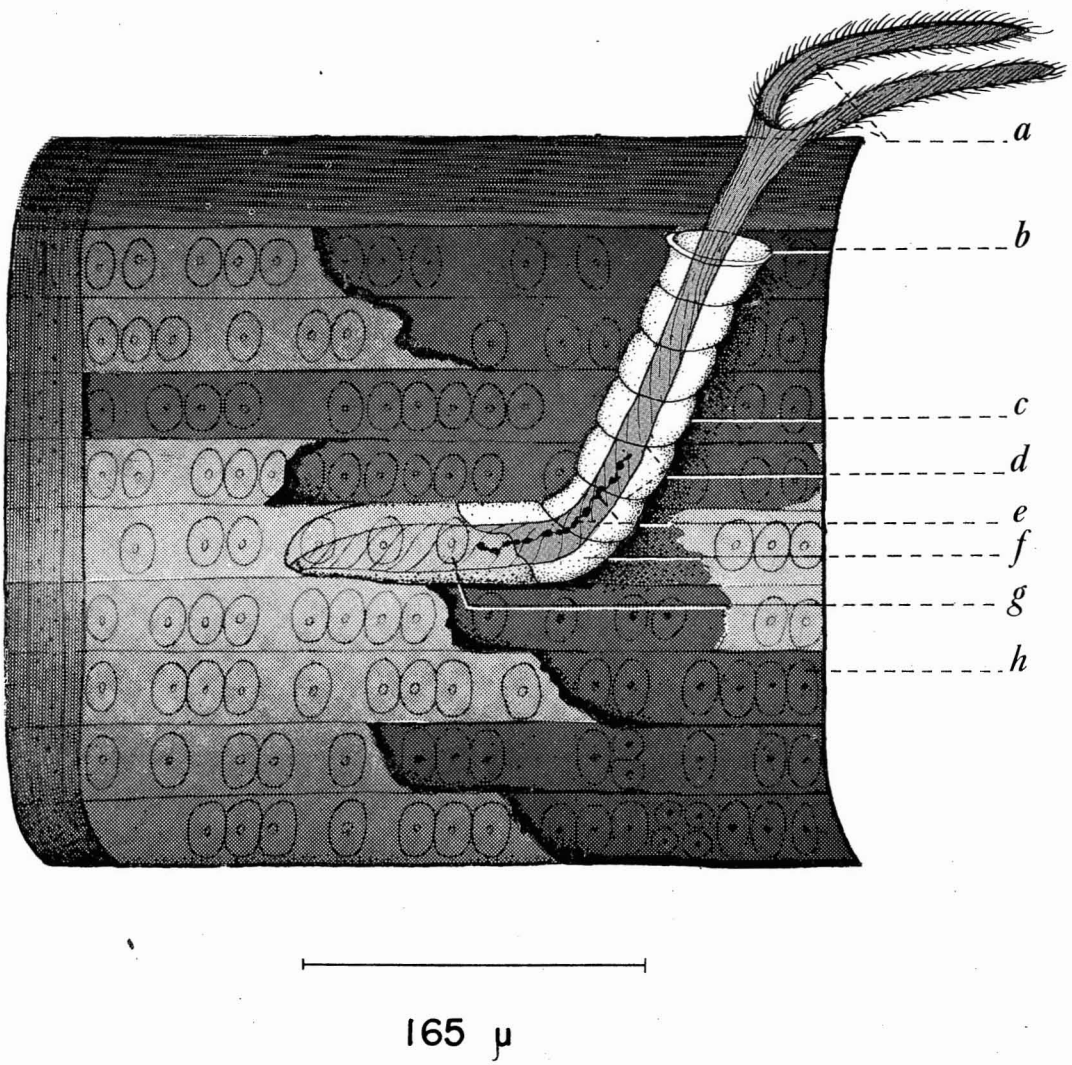


FIG. 1. *Eufolliculina lignicola,* as viewed from the right side showing: *a,* extended peristomal lobes; *b,* distal opening of neck; *c,* neck; *d,* spiral whorls; *e,* nuclear components; *f,* sac; *g,* unopened portion of tracheid; *h,* opened portion of tracheid.

site chosen, neck lengths varied only between 132μ and 167μ with the mean at approximately 159μ. Spiral whorls (*d*) usually numbered six, although occasionally five and seven were observed. The diameter of the neck (49μ) was approximately that of the unrestricted sac.

In reflected light the color of the extended body resembled that of *Parafolliculina violaceae* (Matthews, 1962), except that perhaps in *E. lignicola* the wine color was somewhat more intense. However, in transmitted light the body and lorica appeared bottle-green, a characteristic of most folliculinids. As previously reported (Matthews, 1962), both size and number of nuclear components varied in accordance with body contraction resulting from fixation. Thus, in contracted bodies, nuclear components were large (5μ) and often numbered as few as 6, whereas in more relaxed bodies, nuclear components (Fig. 1*e*) were small (3μ) and often

numbered as many as 12. The peristomal lobes (*a*) were long (approximately 116μ) and in feeding specimens, were carried high above the distal opening of the neck (*b*). No swimmers were observed.

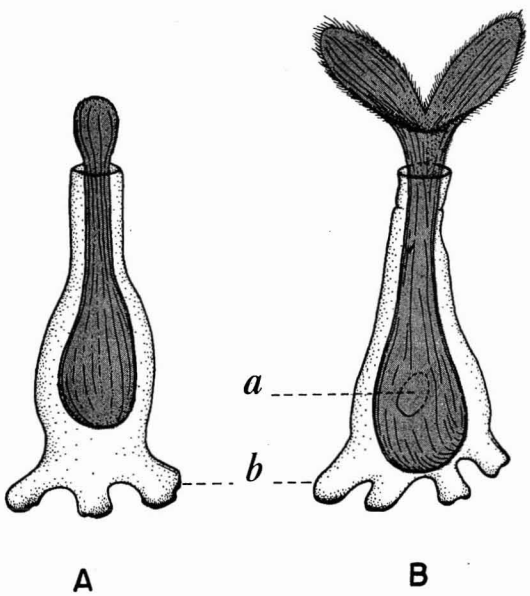
Mirofolliculina limnoriae (Giard 1883) Dons 1927 (*vid.* Fig. 2*A* and *B*)

Freya limnoriae Giard, Bull. Scientific, t.XV: 264–265, 1883.

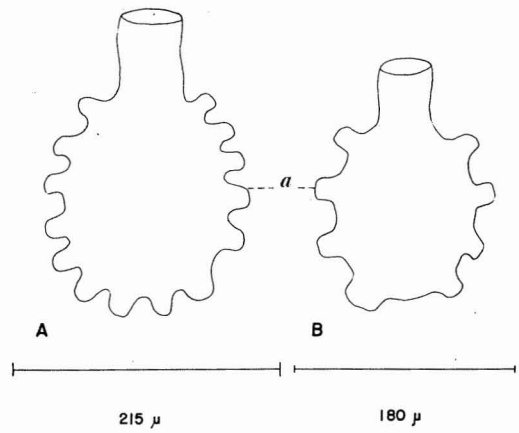
Folliculina limnoriae (Giard) Fragments biologiques XIII. Sur les genres *Folliculina* et *Pebrilla.* Bull. Sci. Nord. 3:310–317, 1888.

Since Giard's publication of *Folliculina limnoriae,* this bizarre folliculinid has been characterized both by its habitat (dorsal surface of *Limnoria* pleotelson or adjacent segments) and by the lateral outpocketings of its lorica (Figs. 2*A, B*; 3*A, B*; 5*A, B*; 6).

Although both Mohr (1959: 86), working on *Limnoria lignorum* of the Pacific coast of North America (Friday Harbor), and Giard (1888:314), working on *Limnoria* (sp.) of the



FIGS. 2*A, B.* Tracings of Giard's plates of *Folliculina limnoria* taken at Wimereux showing: *a,* spherical nucleus; *b,* extent and region of pouches. Magnification not given.



FIGS. 3*A, B. Mirofolliculina limnoriae,* showing: *a,* empty loricae with lateral pouches.

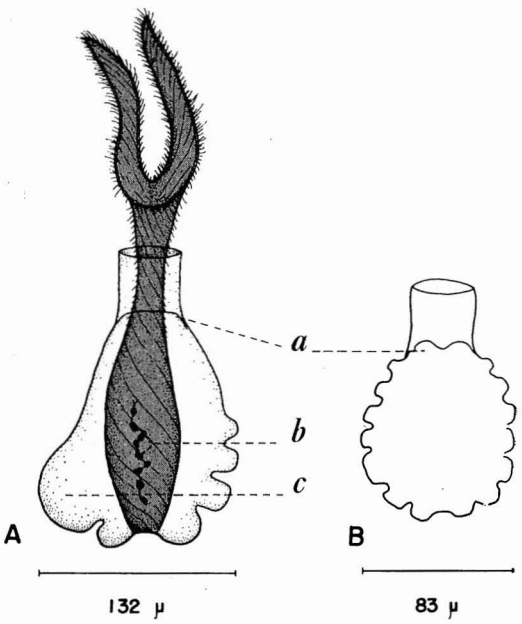
Atlantic coast of France (Wimereux), consider *M. limnoriae* an abundant species, rarely was it observed on *L.* (*Paralimnoria*) *andrewsi* (Coleman) of Hawaii (Menzies, 1959:10). In fact, not until November 29, 1961, after hundreds of gribbles had been examined, were even the empty loricae (Fig. 3*A, B*) observed. This paucity may in part be due to the fact that *M. limnoriae* temporarily had lost its habitat to another, as yet undetermined, organism; for, almost covering the dorsal surface of the pleotelson of every third or fourth gribble examined, was a large brown hemispherical cyst (Fig. 4*a*) which, when opened, liberated two minute unpigmented dorsoventrally flattened worms. This impression is further supported by the fact that during January, 1962, while the numbers of these cysts decreased, the numbers of *M. limnoriae* increased. However, even in old established gribble colonies (such as those from the riddled hull of the "Seth Parker" at Coconut Island) only one *M. limnoriae* was taken for every 21 *L.* (*P.*) *andrewsi* examined.

Of 25 *M. limnoriae* taken at random, the length of the sac varied from 133μ to 216μ, with the mean at approximately 149μ. The sac at its greatest width varied from 83μ to 132μ, with the mean at approximately 116μ. The neck, which was completely devoid of spiral thickenings or proximal lip, varied in length from 49μ to 66μ, with the mean at approximately 59μ.

The diameter of the neck was almost uniformly 50μ, except for those of certain empty loricae whose necks were ellipsoidal; in such instances the greater diameter (at right angle to the longitudinal axis) was roughly 58μ and the lesser diameter 25μ.

The greatest variation was observed in the number, arrangement, and size of the lateral pouches (Figs. 2*A*, *B*; 3*A*, *B*; 5*A*, *B*; 6). Although smaller loricae usually exhibited fewer pouches, this was not always the case. For example, a lorica (Fig. 5*A*) with but 6 pouches (the smallest number observed) was larger than a lorica (Fig. 5*B*) with 16 pouches. (Nineteen was the largest number observed.)

Although each lorica was somewhat swollen at its base, the pouches did not necessarily extend, as did those shown by Giard (Fig. 2*A*, *B*), in finger-like protrusions from the swollen base, nor were they bilaterally arranged. Arrangement of pouches varied from as few as 2 pouches on one side and 4 on the other (Fig. 5*A*) to as many as 9 on one side and 10 on the other (Fig. 6). Figure 5*B* is interesting for not only does it show a bilaterally symmetrical arrangement of the 16 pouches, but the anterior 2 (*a*) are clearly seen through the neck when viewed dorsally; hence similar outpocketings (as in Fig. 6*a*) may have been mistaken for the so-called valves mentioned by earlier investigators.



FIGS. 5*A*, *B*. *Mirofolliculina limnoriae* as viewed from the dorsal surface, showing: *a*, pouches visible through neck; *b*, lobes of moniliform nucleus; *c*, large, lateral pouch.

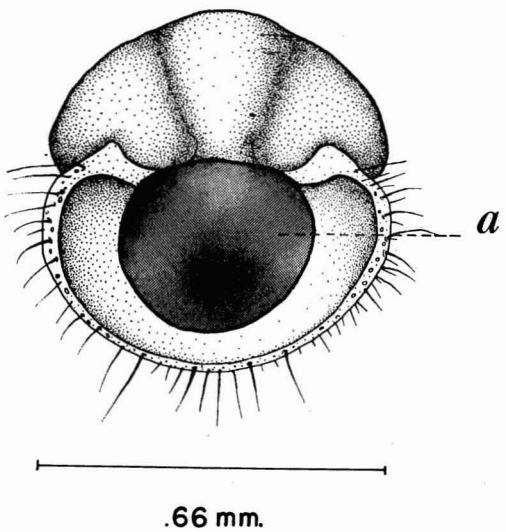


FIG. 4. Pleotelson of *L.* (*Paralimnoria*) *andrewsi*, showing: *a*, large hemispherical cyst on dorsal surface.

Even more variable was the size of the lateral pouches. These ranged from only a few microns (Fig. 6*b*) to half the width of lorica (Fig. 5*A*, *c*). And, although large pouches were usually located posteriorly near the base of the lorica, occasionally they were located anteriorly near the neck. Because to my knowledge the process of lorica formation in this species has not been observed, neither pouches nor their variation in number, arrangement, and size can at present be explained.

Unfortunately, too many observers have been concerned with the unique lorica and too few with the living organism. Even actual descriptions are meager. Giard (1888:315), who attributed to this species a non-moniliform nucleus (Fig. 2*B*, *a*) merely states ". . . [it] is a little smaller than the preceeding species [*Folliculina abyssorum* Giard], of a darker greenish blue with the striation of the integument less apparent. . . ." Kahl (1932) is concerned that

folliculinids of quite varied nuclear components have been assigned to *M. limnoriae.* This is understandable. Since many different species of *Limnoria* have evolved in various regions of the world (Menzies, 1959) one would not expect the folliculinids, with which they are so intimately associated, to have remained constant. In *M. limnoriae,* as was previously pointed out for *E. lignicola,* nuclear components varied with the degree of body contraction following fixation. With peristomal lobes well contracted into the lorica, the nucleus appeared as little more than a dark spherical mass near the point of the body attachment. However, with peristomal lobes relaxed and carried high above the distal opening of the neck, the nucleus appeared as a string of beads whose size and numbers of components varied. The largest number of nuclear components (Fig. 5*A*, *a*) observed was nine (and this was not in a completely relaxed specimen). The question of whether variations in nuclear components and/or variations in number, arrangement, and size of lateral pouches have specific value must await further and more extensive investigations. However, as mentioned by Mohr (1959) some correlation seems to obtain between the latitude in which *M. limnoriae* is found and the degree to which its lorica is branched (compare Giard's figure of *M. limnoriae* from France [Fig. 2*A*, *B*] with my figure of *M. limnoriae* from Hawaii [Fig. 6]).

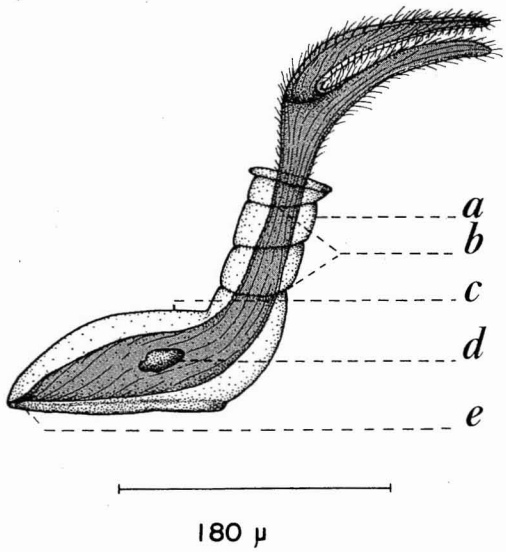


FIG. 7. *Lagotia viridis,* as viewed from the right side, showing: *a,* neck; *b,* three spiral whorls; *c,* non-flattened sac; *d,* spherical nucleus; *e,* non-spatulate foot.

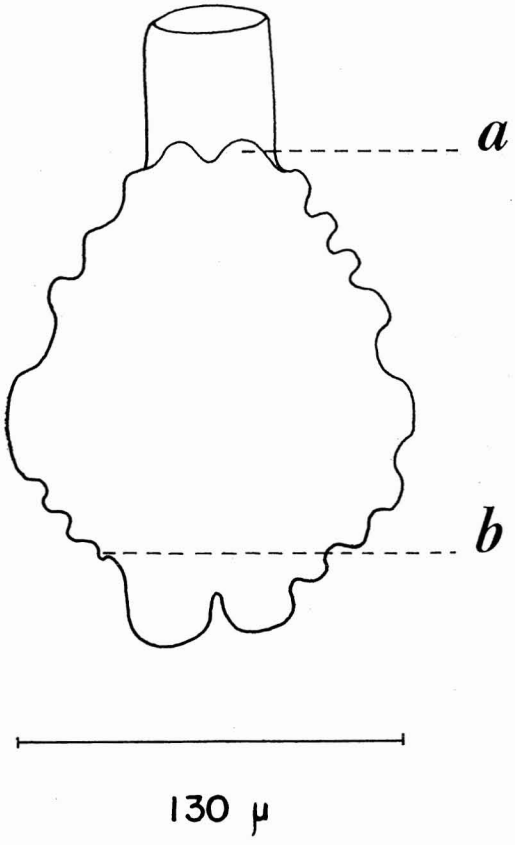


FIG. 6. *Mirofolliculina limnoriae* as viewed from the dorsal surface, showing: *a,* pouch viewed through neck; *b,* an extremely small pouch.

Lagotia viridis, T. S. Wright 1858. Description of New Protozoa. Edinb. New Phil. Journ. New Series, 7:276–281.

While not directly attached either on or in riddled wood panels, *L. viridis* was abundant on and in the empty osseous valves of the prionodesmacean mollusk *Ostria virginica,* which was present on all panels observed. Although, in an earlier publication (Matthews, 1953) *Lagotia simplex* (Dons, 1917) (reassigned by Hadzi, 1951, to *Ascobius simplex*) was also credited with occupying this habitat, there is no

good reason to confuse these related but quite distinct species. Although both species are devoid of vestibule and closing apparatus (valves) and possess spherical nuclei, Hadzi is justified in his reassignment of *L. simplex* to *Ascobius simplex* on the basis of its flattened lorica and spatulate foot; whereas in *Lagotia viridis,* the lorica (Fig. 7*c*) is not flattened nor is the foot spatulate (*e*). For representatives of *L. viridis* in Hawaii an even more obvious difference is at once apparent. Whereas in *Ascobius simplex* the neck is exceedingly short (Matthews, 1952: 344), in *Lagotia viridis* (Fig. 7) the neck (*a*) extends from the sac and is strengthened by two or three spiral whorls (*b*). Moreover, while *A. simplex* is comparatively small, *L. viridis* is comparatively large, often possessing sac lengths of over 180μ and neck lengths of over 100μ.

Thus, to date, folliculinids embracing eight species and seven genera are known from Hawaii. Accepting Hadzi's reassignments, these now stand as: *Halofolliculina annulata* (which I have not yet taken), *Ascobius simplex, Metafolliculina andrewsi, Metafolliculina nordgardi* (which may prove to be a new species), *Parafolliculina violaceae, Eufolliculina lignicola, Mirofolliculina limnoriae,* and *Lagotia viridis.*

It is interesting to note that, whereas *Folliculinopsis gunneri* Dons 1927, reassigned by Hadzi (1951) to *Pachyfolliculina gunneri,* is present on the ventral surface of *Limnoria lignorum* from the Pacific coast of North America (Mohr, 1959:86), not one specimen has been observed on the hundreds of *L.* (*P.*) *andrewsi* which I have examined.

There is every good reason to believe that new records of folliculinids from Hawaii will continue to appear. Re-examination of rather an extensive pagurid collection made over the past 10 years discloses many folliculinids which previously had been overlooked. Although these possess undamaged loricae, their still pigmented but highly contracted bodies are not suitable for specific determinations.

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